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(54) A method of producing large objects from rapidly quenched non-equilibrium powders.

(57) A method of producing large objects from rapidly quenched non-equilibrium powders in which the powder is first slowly precompacted to a predetermined density without causing any substantial temperature rise. The powder is then rapidly compacted by a shock wave having a short rise time. In this way thin surface regions on the particles are rapidly brought to melting to cause interwelding of the particles. These thin surface regions are then rapidly quenched by conduction of heat to the interior of the particles. Because of the very rapid heating and quenching, in the order of a few microseconds, degradation of the material is avoided.

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A METHOD OF PRODUCING LARGE OBJECTS FROM RAPIDLY QUENCHED NON-EQUILIBRIUM POWDERS

The present invention relates to a method of producing large objects from rapidly quenched non-equilibrium powder particles, such as amorphous or supersaturated metal powders.

The materials considered for the present invention have up to now only been producible in thicknesses of 100 μm or less. These materials are produced by rapidly quenching the material from a liquid state. The cooling rate necessary is of the order of 10^6 ^oC/sec. For each material there is a critical temperature which cannot be exceeded, at least not considerably, for more than a short time if degradation of the material is to be avoided. This critical temperature is e.g. about 400°C for the amorphous alloy sold under the trade mark METGLAS 2826. This is far below the melting point of the material. The high cooling rate necessary at the production stage and the impossibility to exceed the critical temperature substantially for more than a very short time has up to now made it impossible to produce pieces having a thickness of more than about 50 μm. For certain materials the maximum thickness is even considerably less, e.g. 20 μm.

The object of the present invention is to suggest a method of producing large objects from rapidly quenched non-equilibrium powder particles. According to the invention it is suggested that these powder particles are precompacted to a predtermined dentisy, e.g. by pressing slowly so that the powder remains substantially at room temperature. The powder is then positioned in a confined space and further compacted by propagation of a shock wave, having a short rise time, through the powder. Since the pressure is increased very rapidly the surface regions of the particles are quickly heated to the melting point of the material to cause interwelding of the particles. The surface

regions of the particles are then rapidly quenched by conduction of heat therefrom to the interior of the particles so that subsequent degradation of the material is avoided.

In order to obtain a satisfactory result it is absolutely necessary that the time during which any part of the material is at a temperature considerably above the critical temperature is very short, should be in the order of a few microseconds or less. It is therefore necessary to heat the material very rapidly so that only the surface regions of the particles reach the melting point of the material. In order not to produce too much heat in obtaining surface melting the powder must be precompacted to a certain density which depends on the material being used. The effect obtained with the precompaction is that the subsequent shock wave will create a much quicker pressure rise in the powder so that the melting point will be reached at the surfaces of the particles with considerably less energy being introduced into the powder. This means that actually only a very small fraction of the powder volume is heated to the melting point of the material. The melting zone is, therefore, only a thin layer at the particle surface. These thin zones are then rapidly quenched by conduction of heat to the interior of the particles. Since the melting zones are thin and thus the volume of melted material small all parts of each particle will be at a temperature below the critical within a very short time, of the order of one microsecond. Since the heating time also is of the order of one microsecond the whole bonding process will be completed within a few microseconds. Since the material then lies at a temperature below the critical temperature, which for iron-based materials is in the order of 400°C, degradation of the material is avoided. It should be noted that particles suitable for being used with the present invention should not be porous because then the interior of the particles would be heated as a result of substantial particle compression.

The amount of precompaction which should be used in order to reduce the amount of energy, and thus the amount of heat, necessary for obtaining surface melting of the particles varies from material to material. Good results have been obtained with iron-based materials when the powder has been precompacted to a density of 40-60 % of that of a solid body.

The size of the objects that can be produced with the method according to the present invention is only limited by the size of the

machine used. The shock wave is preferably created by launching a projectile, which could be of steel, a plastic material or another material, against the powder. Therefore, one can, in principle, make products or objects of virtually any size and of many different shapes if suitable dies are used to confine the powder during the compaction.

With the present invention it is possible to use the special properties which one finds in rapidly quenched non-equilibrium materials for a great number of applications which have been impossible up to now. Such properties could be e.g. high hardness, high ductility, good corrosion resistance, good magnetic properties for amorphous metals, i.e. metals having no crystals. Furthermore, good tool materials can be produced with super-saturated materials, i.e. a material containing substantially more of one or several additives than can be produced with conventional techniques, as well as with the amorphous materials. In addition to this both the amorphous and the super-saturated materials can advantageously be used in other applications where their special properties make them particularly suitable.

Three examples are given below showing that the original non-equilibrium structure of the powder is retained when large objects are produced according to the present invention.

Example 1. An amorphous alloy, sold by Allied Chemical Coropration under the trade mark METGLAS 2826, in form of a ribbon approximately 1.6 mm wide and 50 μm thick was cut into pieces approximately 1 mm long to produce powder. The composition of this material is 40 % Nickel, 40 % Iron, 14 % Phosphorus, 6 % Boron. The powder was precompacted in a chamber of 25 mm diameter to a density of 3.5 g/cm^3 (approximately 45 % of full density). The powder was then impacted by an ertacetal piston of 25 mm diameter and 30 mm long at a velocity of 1500 m/s. The object thus produced was fully amorphous.

Example 2. A M2 Tool Steel Powder of approximately 100 μm particle size, sold by Davy-Loewy Ltd of Bedford, England, having a non-equilibrium structure comprising ferritic and austenitic solid solutions, its composition being Iron base, 6 % Tungsten, 5 % Molybdenum, 2 % Vanadium, 4 % Chromium, and near 1 % Carbon, was precompacted in a chamber of 25 mm diameter to a density of 4 g/cm^3 (approximately 50 % of full density). The powder was then impacted by an ertacetal piston of 25 mm diameter and 30 mm long at a velocity of 2000 m/s. The object thus produced retained the original non-equilibrium structure of the powder.

Example 3. A Grade MD-76 alloyed aluminium powder of approximately 100 μm particle size, sold by Alcan Metal Powders of New Jersey, U.S.A., was given a solutionising and quench treatment to produce a non-equilibrium supersaturated powder solution having the composition Aluminium base, 1.6 % Copper, 2.5 % Magnesium, 5.6 % Zinc, and precompacted in a chamber of 25 mm diameter to a density of 1.7 g/cm^3 (approximately 60 % of full density). The powder was then impacted by an ertacetal piston of 25 mm diameter and 30 mm long at a velocity of 1000 m/s. The object thus produced retained the non-equilibrium supersaturated state of the powder.

Claims

1. A method of producing large objects from rapidly quenched non-equilibrium powder particles comprising positioning the powder in a confined space and propagating a shock wave having a short rise time through the powder to cause interwelding of the particles, c h a r a c t e r i z e d t h e r e b y that the powder is slowly precompacted to a predetermined density before it is compacted by said shock wave in order to reduce the amount of work, and thus the amount of heat, subsequently introduced into the powder by said shock wave, and rapidly quenching the surface regions of the particles by conduction of heat therefrom to the interior of the particles, thereby decreasing the temperature of the interparticle welds to a value below a predetermined critical value so as to avoid subsequent degradation of the material.

2. A method according to claim 1, c h a r a c t e r i z e d t h e r e b y that the powder is precompacted to a density of at least 30 % of the density of a solid body.

3. A method according to claim 2, c h a r a c t e r i z e d t h e r e b y that the powder is precompacted to a density of 40-60 % of the density of a solid body.

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EUROPEAN SEARCH REPORT

Application number
EP 80 85 0098

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US - A - 4 069 045 (B.G. LUNDGREN) * Column 6, lines 24-50 *	1-3	B 22 F 3/08 C 22 C 1/04
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X	US - A - 4 063 942 (B.G. LUNDGREN) * Column 6, lines 14-40 *	1-3	
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A	US - A - 3 157 498 (L. ZERNOW et al.) * Column 2, lines 43-70 *		

TECHNICAL FIELDS SEARCHED (Int. Cl.)

B 22 F 3/08
C 22 C

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10-10-1980	SCHRUERS

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KALIN MECH ENG WKS (MOST) *SU -621-434
13.10.76-SU-423425 *(24.07.78)* B21j-05
Volumetric isothermic stamping of blanks - using loading in stages 'h increasing periods left under load at each stage before relieving

Full Patentees: Kaliningrad Mech. Eng. Wks.; Moscow Steels and Alloys Inst.
Blanks can be stamped by a volumetric isothermic process. In order to enable universal hydraulic presses to be used, the stamping is done by loading in stages with increasing periods left under load after each stage. To improve metal flow conditions, the deforming force is removed at the end of each period under load.

DETAILS
The blank, pre-heated in a furnace to stamping temp. is carried into an isothermic unit and the working stroke of the press is made at constant speed, giving a certain de-gree of deformation (approx. 25-30%).
Without relieving the deforming force, it is left long enough for the relaxation processes to take place in the metal. The deforming force is then relieved. The next cycle is for a longer time and total degree of deformation.
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